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Brief paper

Improvement of intelligent methods for evaluating the apparent quality of knitted fabrics

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ABSTRACT

In the previous studies, the standard boards of yarn (ASTM) were analyzed using the image analysis method and artificial neural networks; the appearance of different knitted fabrics samples was tested for appearance. There was a strong influence of yarn type and fabrics structure on fabrics apparent quality. In the present research, the artificial neural network (ANN) has been applied to predict the fabric apparent parameters. The optimum structure of ANN has been designed using the genetic algorithm method. The results show that the ANN can be optimized very well by the GA and the designed ANN is very accurate and applicable to predict the apparent parameters.

1. Introduction

The apparent quality can be divided into two categories. First, the fabrics with a large number of area faults that were occurring in the knitting process and eventually make them useless. In the second category, there are inputted faults that originate from yarn faults. The standard method ASTM (Mahli and Batra, 1972) is for grading the short staple spun yarn. This standard is based on human observations and therefore it is not precise enough (Semnani et al., 2005). Many researchers like Neval et al. (1996a, 1996b, 1996c) worked to solve this problem that was based on classification of events along a thread of yarn by measuring the percentage of different classes of events. In the Fredrych and Matusiak (2002) method, the nep number in cotton yarn was predicted by Uster tester. In another method (Rong and Slater, 1995; Rong et al., 1995), grading of various yarns is done by cluster analysis. The other researchers such as Kang et al. (2001) and Sawhney (2000) used image analysis to detect weaving and yarn faults. Few researchers worked on the classification of weft knitting faults like Abou-liana et al. (2003), whose method was based on structure changes and similar work by Tanako et al. (2004) using image analysis and 3D-CAD for knitting fabrics. None of the works above present a general method of grading fabric and yarn together based on their appearance, so the aim of the Semnani et al. (2005) investigation was to present a general method for inspecting all types of woven and knitted fabrics. In this research, our attempt is to improve the previous method of fabric apparent quality evaluation by using a developed neural network and genetic algorithm.

2. Material and method

The apparent quality of yarn is directly related to the configuration of fibers on its surface. The knitting faults such as cracks, holes, drop stitches, stripes and distorted stitches make the knitted fabric useless. Therefore, only the appearance of the safe knitted fabric without any knitting faults, tightened fibers with uniform configuration, big faults with less area in comparison with first category, non-uniform and extended faults with spread configuration, and small spread faults such as non-uniform coating fibers and short tangled hairs has been considered. To consider the effect of yarn appearance on the apparent quality of various knitted fabrics, eight categories of different yarn counts and types were prepared including cotton ring spun yarn of 20 and 56 Tex, cotton rotor spun yarn of 20 and 56 Tex, filament yarn of 16 and 33 Tex and acrylic yarn of 20 and 80 Tex. There were four different samples in each category and from each set of samples, three different kinds of fabric were knitted such as plain, cross-miss and plain pique fabrics.

Photographs of standard yarns, from their appearance, were classified into four grades, scanned, then the images were converted to binary images by using $T_t = \mu_t - \sigma_t$ where T_t is an optimum threshold point, and μ_t and σ_t are mean and standard deviation of image matrix, respectively, for detecting yarn faults.

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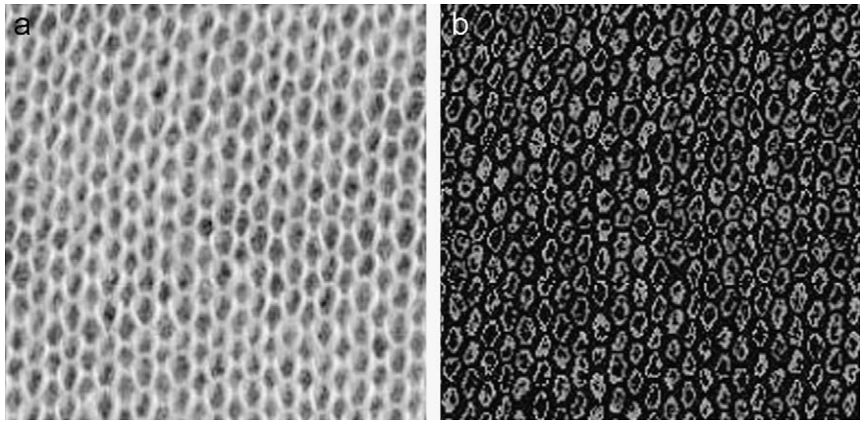

Fig. 1. A sample of knitted fabric (a: Original fabric image and b: By using tow thresholds, background and loops pixels are replaced with zero values. The remaining matrix is matrix of faults image).

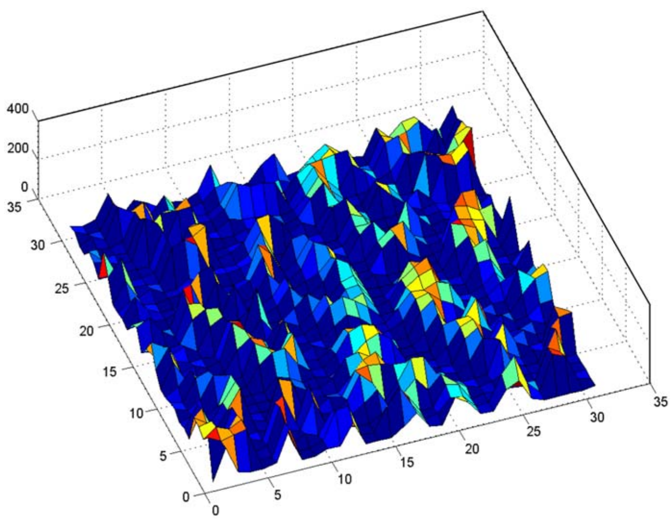

Fig. 2. A part of mesh of binary image fabric, which was shown in Fig. 1b. The vacant places indicate the faults.

Consequently, the image of fabric faults as image of yarn faults can be obtained considering the use of two threshold points: upper point $T_{fl}=\mu_f-\sigma_f$ and lower point $T_{fu}=\mu_f-\sigma_f$. The original images of fabric samples well before and after thresholding operation are both shown in Fig. 1.

To count the faults, their size and adherence was considered for defining a suitable block size that provides maximum deviation in images fault means. The faults of each loop of knitted fabric are separated by neighborhood loops. Therefore, suitable block size of fabric faults image is estimated from loop size, which is approximately four times of yarn diameter.

The faults matrix is divided into blocks of equal size. There are four classes: Class I: $\mu_{bi}\geq 1.2T_{bm}$; Class II: $T_{bm}\leq\mu_{bi}\leq 1.2T_{bm}$ and $V_{bi}\leq T_{bv}$; Class III: $T_{bm}\leq\mu_{bi}\leq 1.2T_{bm}$ and $V_{bi}\geq T_{bv}$; and Class IV: any other blocks of faults image of yarn that are not classified in the above classes. T_{bm} is the threshold of mean blocks, T_{bv} the threshold of deviation blocks, μ_{bi} and V_{bi} are the mean and standard deviations of *i*th block, respectively. The N_1, N_2, N_3 and N_4 for classes I, II, III and IV are the faults countered, respectively. The fault percent in each class can be calculated by $PF_i=(N_i\times K\times K)/(M\times N)$, i=1,2,3 and 4 (faults factors). $k\times k$ and $M\times N$ are the size of block and the original image, respectively, in the previous research (Semnani et al., 2005). But in the present work PF_i is the percent of faults volume in each class. Fig. 2 shows a part of binary image mesh (Fig. 1b). The vacant places indicate the faults and so PF_i is the volume of the vacant place to whole volume; thus the sections of fabric that were fault and miscalculated in previous work, has been considered as fault; therefore this method can obtain more accurate results than previous work.

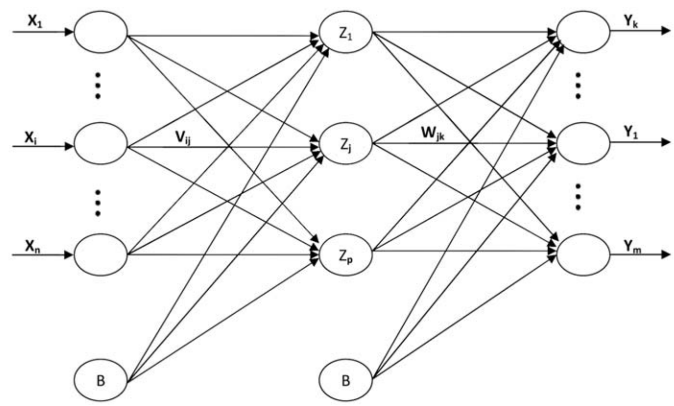

Fig. 3. Neural network (back-propagation) structure by one hidden layer.

Our criteria to apparent quality fabric is $I_D=WP$ where W is a vector 1×4 of faults weight and P is a vector 4×1 of faults factors. Standard board images are used for estimation of the faults weights (Semnani et al., 2005).

3. Neural network model

Nowadays, the neural networks are used in many problems to predict various processes. In this model, the least unit former is called a neuron, which can be divided into three layers: input layer, hidden layer and output layer. The hidden layer itself can be formed from some hidden layers. Fig. 3 shows an ANN by one hidden layer.

Each output unit y_k is computed by Eqs. (1)–(5) where x_i, z_j and y_k are input signals, output activation for hidden layer and final ANNs output, respectively:

$$z-in_j=v_{oj}+\sum_{i=1}^{n}x_iv_{ij} \tag{1}$$

$$f(x)=\frac{e^x-e^{-x}}{e^x+e^{-x}} \tag{2}$$

$$z_j=f(z-in_j) \tag{3}$$